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A Comparison of Capacity for Resilience Among Coastal Communities in the Northeast U.S. and the Northern Gulf of Mexico Region

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A COMPARISON OF CAPACITY FOR RESILIENCE AMONG COASTAL COMMUNITIES IN THE NORTHEAST U.S. AND THE NORTHERN GULF OF MEXICO REGION

A Thesis

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ABSTRACT

Coastal communities face many threats from their surrounding environment, including floods and severe storms. These threats are exacerbated by climate change and sea level rise, which may cause increased frequency and severity of these events. Despite these hazards, population density along the coasts continues to rise. These areas of dense population and infrastructure are highly vulnerable to extreme weather events. Hurricane Sandy of 2012 was a powerful demonstration of the impact that severe storms can have on coastal populations. In the face of this reality, coastal communities must adapt and become more resilient to environmental changes. In order to assess the relative capacity for resilience of communities in the Northeastern U.S., I created a Resilience Capacity Index following the methods of Baker (2009) and Reams et al. (2012). I analyzed 43 variables for 60 coastal communities in New York and New Jersey. I used a principal component analysis, which resulted in 6 components explaining 72% of the variance. The results were compared to those of Cutter et al. (2003) and Reams et al. (2012). Finally, I performed a bivariate analysis to determine if there was a correlation between post-disaster federal assistance and resilience capacity. The results show that New Jersey has an overall higher resilience capacity than New York, and that within New York, the counties along the Great Lakes had a lower capacity for resilience than the counties on the Atlantic coast of the state. While the results of the study show interesting patterns of resilience capacity, verification methods are needed to validate findings of resilience capacity. Nevertheless, policy-makers can use these results to hone in on areas that need further study.

CHAPTER 1: INTRODUCTION

The coastline of the United States faces a number of threats from flooding, storms, subsidence, and erosion, yet the population of the US continues to be drawn to the coast. According to the National Oceanic and Atmospheric Administration (NOAA) over half of the US population lives along the coast, which comprises only 17% of the nation’s land area (NOAA 2013a). According to the H. John Heinz III Center for Science, Economics and the Environment (2002) 14 out of the 20 largest US cities are on the coast. Development along the coast is occurring at an even faster rate than population growth. This trend is diminishing the coast of its natural resources causing an artificial land loss (Hudson 2012). Rapid urbanization of the coast results in environmental degradation that can enhance the threat of coastal hazards as well as increase the impact of extreme weather events (Nichols et al. 2007). The high density of population and infrastructure along the coast makes these communities extremely vulnerable to coastal hazards.

In the past decade, we have seen increases in dramatic weather events, which greatly affect the coasts of the US. In their latest report from 2013, the Intergovernmental Panel on Climate Change (IPCC) predicts that these events will only become stronger and more frequent. Additionally, sea level continues to rise, threatening low-lying coastal areas (Church et al. 2013; Cubasch et al. 2013; Christensen et al. 2013; Heinz Center 2002). Because of these hazards, many protection measures have been put in place such as floodwalls and levees; however, this can sometimes further exacerbate the problem. Coastal hazards and disturbance can come at a great cost, not only to infrastructure, but also to the environment and natural resources, social capital, public health, and the economy (Heinz Center 2002). Such threats to coastal communities from the environment were never more apparent than after Hurricane Katrina in 2005 and Hurricane Sandy in 2012.

Seven years after Hurricane Katrina ravaged New Orleans and the Gulf Coast, Hurricane Sandy hit the northeast coast, devastating communities in New York and New Jersey. Hurricane Sandy became the 18th named storm of the 2012 hurricane season on October 24, 2012. On October 28, 2012, President Obama declared a state of emergency in Connecticut, Washington, D.C., Maryland, Massachusetts, New York, and New Jersey, which made federal support available to save lives and protect property. The President was briefed at the FEMA National Response Coordination Center, and "more than 1,032 FEMA personnel were positioned deployed [sic] along the East Coast working to support disaster preparedness and response operations, including search and rescue, situational awareness, communications and logistical support" (FEMA 2013c).

On October 29, 2012, Hurricane Sandy approached the Northeast United States as a Category 2 storm with hurricane force winds extending 175 miles from the eye. The storm was reduced to a post-tropical cyclone before making landfall in southern New Jersey. On October 30, 2012, 8.5 million households and businesses in 15 states were without power. The lack of power created gas shortages throughout the region and on November 3, 2012, 12 counties in New Jersey began gas rationing. On November 7, 2012, less than 2 weeks after Sandy made landfall, a nor'easter, "a strong low pressure system with powerful northeasterly winds coming from the ocean ahead of a storm," affected already damaged areas of the Northeast (FEMA 2013c). Just one month after Sandy hit, Governor Cuomo of New York estimated that Hurricane Sandy cost New York state $41.9 billion (CNN 2013). As of October, 2013, FEMA allocated over $1.4 billion in individual assistance grants to more than 182,000 survivors. The National Flood Insurance Program paid out over $7.9 billion to policy-holders (FEMA 2013d).

Although the full extent of damage from Hurricane Sandy is not yet known, many comparisons have been made between it and Hurricane Katrina nonetheless. Property damage, money spent on recovery, and fatalities all play in to the measurable effects of these storms. Hurricane Katrina resulted in $134 billion of total damages and 1,883 fatalities, while Sandy cost over $65 billion (NOAA 2013a; NOAA 2013c). Hurricane Katrina was touted as a national failure, yet response to Hurricane Sandy seemed relatively swift, leading people to believe that the federal government learned a valuable lesson from Katrina (CNN 2006; Walsh 2012). According to Federal Emergency Management Agency (FEMA), 95% of debris from Hurricane Sandy was removed just 100 days after the storm hit the area (FEMA 2013d). Some discourse leads us to believe that the communities living on the coast of the northeast were more resilient and made a faster recovery (LiveScience 2012). Whether or not this assumption is factual or just rhetorical remains to be seen. However, assessing the vulnerabilities of these regions may shed light on whether or not the northeast was more prepared for a large storm.

Due to the trends of increasing population densities along the coast, as well as more frequent and extreme environmental events, coastal communities will need to be able to adapt in order to continue to live in hazardous environments. However, the capacity to adapt can be hindered by socioeconomic characteristics. These qualities create a potential for loss, or vulnerability, in coastal communities (Cutter et al. 2003). Funds have begun to be allocated toward adaptation but there is no method yet for deciding where to allocate funds so that they are used most effectively (Ford et al. 2013). Identifying the characteristics that increase vulnerability can help policy makers assess the capability of these communities to adapt to increasing environmental pressures and may help in distributing funds to those communities in most need.

Resilience, or the ability to recover after a disturbance, is difficult to measure, but assessing vulnerabilities within communities can implicate which changes communities can make to become more resilient. Using the methods provided by Cutter et. al (2003) and Reams et al. (2012), I will measure the capacity for resilience of 60 coastal counties in New York and New Jersey (see Figure 1). Using a rotated principal component analysis I will identify which of 43 variables are most indicative of resilience capacity, and I will determine which coastal counties in the Northeast may have a greater capacity for resilience. Then, I will compare the scores in the Northeast and Gulf Coast to determine if perhaps there really is a difference in the capacity for resilience in the two regions. Finally, I will conduct at bivariate analysis to determine if there are any correlations between FEMA Public Assistance Grants and relative resilience capacity.

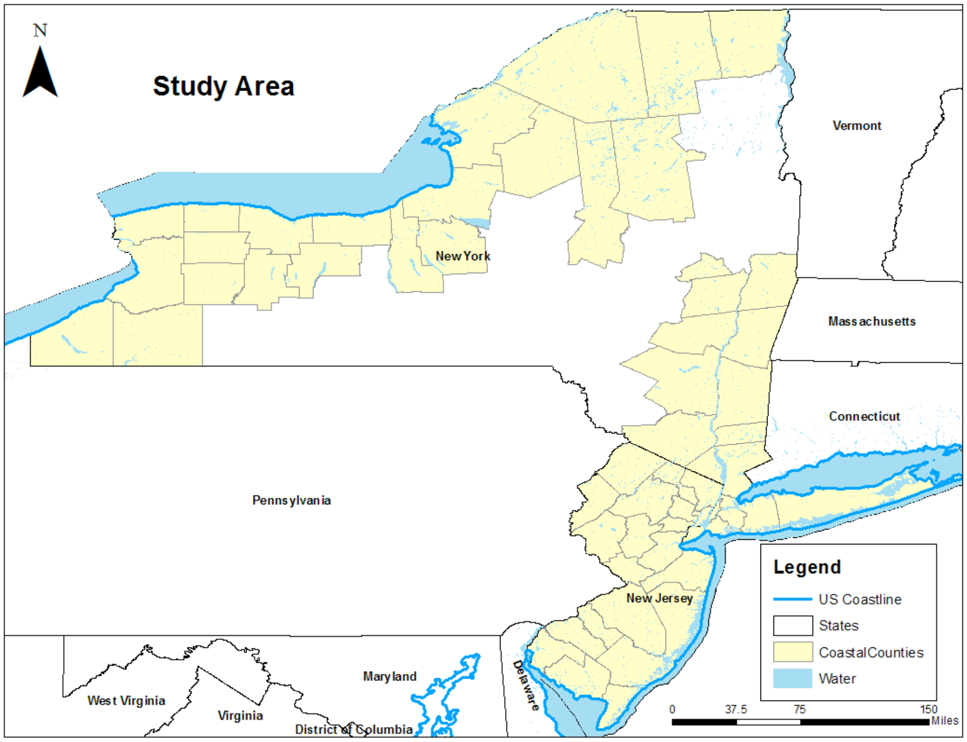

Figure 1. Study Area

CHAPTER 2: RELATED RESEARCH

2.1 Coastal Hazards

According to the Merriam-Webster dictionary, a hazard is defined as "a source of danger" (http://www.merriam-webster.com/dictionary/hazard). Coastal areas are increasingly threatened by climate-related hazards, which are exacerbated by climate change. These hazards can be either slow-moving or fast-moving variables within the system. Slow-moving hazards are large-scale variables that exist within a large spatial and temporal extent. Sea level rise and climate change are examples of slow-moving hazards that pose threats to coastal cities. However, even though these hazards threaten the system, the slow-moving nature of them allows for a somewhat stable system. Fast-moving hazards can occur within the system created by slow-moving variables. For example, in the context of climate change and sea level rise, hurricanes and floods can pose an immediate threat to a system and knock it out of its stable state. The slow-moving and fast-moving systems also interact with each other and can make impacts worse (Armitage and Johnson 2006; Folke 2006; Gunderson 2000). Thus extreme coastal hazards like floods and hurricanes, along with climate change and sea-level rise pose serious threats to coastal communities.

The newest IPCC report (2013) has concluded that projections of global sea level rise have become more certain based on improved scientific understanding and climate models. Sea level rise, caused by glacial melt and thermal expansion, will have a great effect on coastlines globally. However, relative sea level rise could more greatly affect coastal populations in the Northeast due to the combined impacts of eustatic (global) sea level rise and local subsidence (Church et al. 2013). In an assessment performed by the New York City Panel on Climate Change in 2011, Horton et al. projected higher sea level rise in New York City than the global average. They project that in a rapid ice melt scenario, relative sea level could rise approximately 2 meters. While this is a high estimate, it could be used to adequately assess the risks to infrastructure and development in the region. Horton et al. also find that using IPCC's AR4 report projections, the city could see an increase in the frequency of 1-in-10 year flooding events by 2080. Keeping in mind that the exact projections are always uncertain, climate models consistently predict increases in the frequency of extreme weather events like flooding and storms and project a rise in sea level.

2.2 Coastal Policy

As a result of the vulnerabilities induced by coastal hazards and development, the federal government has developed a number of policies, like the Coastal Zone Management Act, which aim to regulate the use of the coastal zone. The Coastal Zone Management Act (CZMA) is a voluntary program that was enacted in 1972. According to the statute, states are given guidelines from which to create comprehensive management plans for their coastal zones. Coastal zones are defined for each state that has an approved Coastal Management Plan (CMP) (NOAA 2013b). The coastal zone should "encompass all important coastal resources including transitional and intertidal areas, salt marshes, beaches, coastal waters and adjacent shorelands where activities have the potential to impact coastal waters" (New Jersey Department of Environmental Protection 2002a). Generally state coastal zones extend three nautical miles into the sea (NOAA 2012a). The CZMA is implemented by the states according to their CMPs and federal consistency is required. The federal consistency program within CZMA ensures any federal action is consistent with an approved state coastal zone management plan. Federal consistency is an incentive for states to participate in the program, but it also creates inconsistencies from state to state since the decision-making is primarily in the hands of state government. Coastal

Management Programs can help coordination on a state-wide level of all agencies involved in coastal policies and can expedite permitting processes among other factors. (NOAA 2013b; Heinz Center 2002). The CZMA, has its advantages and disadvantages, which we will look at for both the state of New York and New Jersey.

2.2.1 New York Coastal Management Plan

The boundary for the coastal zone in New York as it applies to the CZMA is defined as such:

> New York's coastal zone varies from region to region while incorporating the following conditions: The inland boundary is approximately 1,000 feet from the shoreline of the mainland. In urbanized and developed coastal locations the landward boundary is approximately 500 feet from the mainland's shoreline, or less than 500 feet where a roadway or railroad line runs parallel to the shoreline at a distance of under 500 feet and defines the boundary. In locations where major state-owned lands and facilities or electric power generating facilities about the shoreline, the boundary extends inland to include them. In some areas, such as Long Island Sound and the Hudson River Valley, the boundary may extend inland up to 10,000 feet to encompass significant coastal resources, such as areas of exceptional scenic value, agricultural or recreational lands, and major tributaries and headlands (NOAA 2012a).

According to the New York Department of State (NYDOS), their CMP, approved in 1982, helps coordinate efforts throughout the state. It also helps in addressing 9 major issues facing the state, including “promoting waterfront revitalization; promoting water dependent uses; protecting fish and wildlife habitats; protecting and enhancing scenic areas; protecting and enhancing historic areas; protecting farmlands; protecting and enhancing small harbors; enhancing and protecting public access; providing solid and useful data and information on coastal resources and flooding hazards” (New York Department of State 2001). New York’s CMP promotes the use of coastal benefits, but also realizes prudent use of coastal resources is necessary for sustaining society and the environment. Areas protected under the New York CMP are:

- significant fish and wildlife habitats
- the traditional character and purposes of small harbors
- historic and cultural resources
- exceptional scenic areas
- agricultural land
- dunes, beaches, barrier islands and other natural protective features
- water and air resources
- wetlands

(New York Department of State 2001).

Many of the coastal policies are regulated by the state's Department of Conservation. However, policies such as those promoting revitalization along the waterfront only seem to make coastal communities more vulnerable. For example, Policy 1 under Development Policies encourages economic stimulation and development along waterfronts such that "uses requiring a location abutting the waterfront must be given priority in any redevelopment effort" (New York Department of State 2001). As is demonstrated in the literature, industrialization and urbanization of the coastline is not conducive to becoming a more resilient community. On the other hand, Policy 11 of the CMP regulates that buildings be sited in a way that minimizes endangerment of life and property due to flooding and erosion. This involves utilizing setbacks and requiring permits in order to build in erosion hazard areas. The policy also requires a disaster management preparedness program. Additionally, Policy 12 provides for the protection of natural resources that provide flood and storm protection such as beaches, dunes, barrier islands, and bluffs. The CMP also promotes using non-structural means of protecting natural resources, including setbacks, restoring coastal landforms through planting vegetation and building sand fences, and regulating building on erosion and high water hazard areas (New York Department of State 2001). These are just a few of the policies outlined in New York's CMP, but they demonstrate a will to balance both economic development with social-ecological resilience. Whether these measures result in real community resilience will be examined below.

2.2.2 New Jersey Coastal Management Plan

According to NOAA, the state of New Jersey comprises 1792 miles of coastline (NOAA 2012b). New Jersey's Coastal Management Program (NJCMP) defines its coastal zone to encompass "all areas where the state has authority, through the Department of Environmental Protection and the New Jersey Meadowlands Commission, to regulate land and water uses that may have significant impact on coastal resources" (New Jersey Department of Environmental Protection 2002a). Within New Jersey's CMP, it has 3 primary statues with which to regulate coastal uses. The first is the Coastal Area Facility Review Act (CAFRA), which regulates the "location, design, and construction of major facilities in the 1376 square mile coastal area" (New Jersey Department of Environmental Protection 2002a). The CAFRA area which falls under this regulation includes beaches and dunes as well as land from the mean high tide marker inland. The width of the area varies across the state. The next statute is the Waterfront Development Law, which "protect and maintain navigation and commerce on and adjacent to New Jersey's tidal waterways" (New Jersey Department of Environmental Protection 2002a). Finally, the Wetlands Act of 1970 serves to regulate the use and disturbance of coastal wetlands through the New Jersey Department of Environmental Protection (NJDEP). Coastal wetlands are defined as those that are influenced by tidal action (New Jersey Department of Environmental Protection 2002a). Under section 309 of the CZMA, New Jersey instituted an Ocean Resources Management Plan (ORMP). The ORMP strives to find a sustainable balance between commercial and recreational uses as well as protecting the health of the environment for its residents and visitors. The ORMP goals also entail effective management of ocean resources through improved coordination with different levels of government and different agencies which all have a stake in New Jersey's ocean resources (New Jersey Department of Environmental

Protection 2002b). The policies enacted under the NJCMP are an attempt to enhance the coast and promote resilient communities. The analysis below will provide insight into whether these communities do have a high capacity for resilience.

2.3 Resilience

The theory of resilience stems from the field of ecology, which focuses on the functioning of systems as a whole, not the functioning of its parts alone. Over the past few decades, the amount research on resilience, vulnerability, adaptation, and mitigation has grown, which has led to many definitions of resilience and its related subjects. Two main categories of resilience defined in the literature are engineered resilience and ecological resilience. Engineering resilience is the ability to return to a prior state after a disturbance and “focuses on maintaining efficiency of function, constancy of the system, and a predictable world near a single steady state” (Folke 2006). However, as we have seen from the increase in coastal hazards and frequency of extreme events, the world is not predictable. Therefore, we will focus on what is called ecological resilience. Ecological resilience theory states that there are multiple stable systems, and resilience is the measure of how much disturbance a system can withstand before it shifts to another state (Gunderson 2000). Folke (2006) argues that ecological resilience differs from engineering resilience by showing a “capacity for renewal, re-organization and development,” and after a disturbance, ecologically resilient systems have “the potential to create opportunity for doing new things.” Like ecological systems, which depend not on individuals, but the functioning of the system as a whole, social resilience relies on the functioning of its communities rather than its individuals, as well as how the society is functioning in conjunction with the environment (Adger 2000).

Resilience cannot be explained or expected without acknowledging the interdependency of social and ecological systems. Ecosystem services provide many benefits to society including fishing and other economic activities. They also provide natural buffers to floods and storms, and humans, especially within coastal communities, are reliant upon natural resources for their survival. However, dense populations along the coast degrade these environments and physically inhibit their adaptation to variability in the environment (Heinz Center 2002). Thus, communities must adapt in ways that allow for the functioning of the environment on which it depends.

Resilience is sometimes referred to as adaptive capacity or “the ability or potential of a system to respond successfully to climate variability and change, and includes adjustments in both behavior and in resources and technologies” (Adger et al. 2007). Adaptive capacity captures the ability of a system to shift between multiple stable states (Gunderson 2000). Resilience requires the ability to adapt and develop in response to change. Colten and Giancarlo (2011) acknowledge this when they define resilience as the ability of communities to “rebound to a previous condition or to a functional state after a disruptive event,” and “the ability of humans to adapt in such ways that subsequent and comparable events will be less disruptive.” Thus the crucial component of resilience lies in adaptation and minimizing risks associated with vulnerabilities.

2.4 Adaptive Cycle

As mentioned above, there are fast and slow-moving variables within a system that affects its resilience. These variables are not limited to coastal hazards, but can be sociological in nature, such as social values (slow-moving) or political preferences (fast-moving) (Armitage and Johnson 2006). These variables play into what Holling (1986) first defined as the adaptive cycle. The adaptive cycle contains four stages including exploitation, conservation, disturbance, and reorganization. While Holling initially was describing ecological systems (i.e. biophysical systems), the adaptive cycle can be applied to social ecological systems as well. The exploitation phase described by Gunderson (2000) as “the rapid colonization of recently disturbed areas” can be seen in social systems when rapid development occurs in an area. It is followed by the conservation stage, which is considered the maturation of the system, where energy and material are consumed and stored. While there is still growth, there is less room to do so, and resources become limited, so the system becomes “brittle” and susceptible to vulnerability (Gunderson 2000). Eventually there is a disturbance. Often the disturbance to social-ecological systems is a natural disaster or hazard, such as a hurricane or flood. This phase is destructive to the system, yet it creates opportunity for new growth. Finally, there is the reorganization phase. This allows the system to cycle back to the exploitation phase (Gunderson 2000). It is the slow-moving variables that are dominant within the exploitation and conservative phases. But growing accustomed to a stable system makes the system brittle and vulnerable to fast-moving variables that can destabilize it, which is seen in the disturbance phase (Armitage and Johnson 2006). The system’s resilience and adaptive capacity is revealed through its ability to reorganize and make the changes necessary for the system to thrive again.

2.5 Vulnerability

Vulnerability is associated with resilience in that vulnerable systems are often explained as the opposite of resilient systems. Adger (2000) points out the relationship between resilience and vulnerability. He defines social vulnerability as “the exposure of groups of people or individuals to stress as a result of the impacts of environmental change” encompassing “disruption to livelihoods and loss of security.” Vulnerability however, is not always easy to compartmentalize because it holds different meanings within different contexts, it is difficult to measure, and is inconsistent throughout space and time (Cutter 1996). In order to solve this problem within the discourse of vulnerability, Cutter (1996) defined three major categories. They are “vulnerability as risk/hazard exposure, vulnerability as a social response, and vulnerability of place.” This paper approaches vulnerability as a vulnerability of places, or vulnerability specific to a certain area or region.

Understanding what factors make communities more vulnerable helps us to assess the community’s capacity for resilience and ability to adapt. Social vulnerability, or vulnerability at an individual and community level, is not easy to quantify, yet it is necessary for addressing the ability of a community to respond to social hazards. It is important to consider demographic and economic characteristics that may contribute to a community’s vulnerability (Cutter 1996; Adger 2000). Some factors that may indicate vulnerability are age, race, education, income, unemployment, family structure, and population (Cutter et al. 2003; Heinz Center 2002). Some emphasize that it is the disparities among these factors wherein lies vulnerability. These indicators will differ spatially and temporally as a result of the vulnerability of places.

Although highly related, there are some differences in the concepts of resilience and vulnerability found in the research. Resilience and vulnerability are often disjointed in the literature due to different understandings of the terms in both disciplines, different methodologies, and different methods of assessment and evaluation. Resilience is based in ecological theory while vulnerability research stems from political and social sciences. These differences conceptually often lead to different methodologies when assessing resilience and vulnerability (Miller et al. 2010). However, greater integration of the two disciplines is occurring and my assessment of resilience in the Northeast attempts to include theoretical frameworks from both branches of study.

2.6 Adaptive Governance

Resilience theory has played a role in changing the way we think about planning and management of the coastal zone. Resilience literature emphasizes the inevitable changing nature of social-ecological systems. Thus, management of these systems must be flexible. Instead of focusing on merely controlling the system and preventing it from changing, adaptive management focuses on “managing the capacity of social-ecological systems to cope with, adapt to, and shape change” (Folke 2006). Societies must shift from a rigid structure of controlling “stable” systems to a more readily adaptable system able to develop despite sudden changes (Folke et al. 2005). While the term “adaptive management” is often used to describe the active management of ecological systems, “adaptive governance” has been used to describe the complex nature of the management of both social and ecological systems (Folke et al. 2005). According to Boyle et al. (2001), governance is the combined effect of vision, operationalization or management, and monitoring of social-ecological systems.

Social capital and social memory are both essential to the framework of adaptive governance and adaptive capacity (Folke et al. 2005). Social memory can enhance resilience when past events are not only remembered, but are used to gain knowledge and are used in plans for the future. Almost like a fable, these stories are passed down through “public accounts, lores and myths, and professional practices” to demonstrate what can happen when adequate preparations are not taken (Colten & Giancarlo 2011). However, many of these communities face the erosion of their memory over time. Many times after a catastrophic event, such as a large storm or flood, the memory of the event fades, leading to ill-conceived policies or a lack of preparation. The community’s ability to learn from past events is essential for building resilience and responding to surprises (Adger et al. 2005). The capacity of communities and individuals to learn from experience and retain knowledge and skills is important in adaptive management. The knowledge and skills accrued through social memory can transcend into organizations and institutions and help managers and planners to instill adaptive governance into social-ecological systems (Folke et al. 2005).

2.7 Related Studies

As a result of the lack of concrete measurements of vulnerability, Cutter et al. (2003) developed a Social Vulnerability Index (SoVI). The SoVI quantified the relative social vulnerability of the United States at the county level and helped to identify indicators of social vulnerability. Cutter et al. used a factor analysis to identify which of 42 variables are most indicative of social vulnerability for counties in the US. However, addressing social vulnerability at such a large scale creates a problem of smoothing over intricacies that may tell us more about specific regions. The US has a vast array of geographies each with its own biophysical and social makeup that could be left out when addressing it as a whole. Because vulnerability differs temporally and spatially, the SoVI could not capture the intricacies of each region.

Comparing the vulnerability of counties within the same region will show more about those communities because they have similar biophysical systems and social constructs. Baker (2009) expanded on Cutter's method for the SoVI and produced a method to quantify and assess the factors associated with resilience in coastal communities along the five Gulf Coast states. This method was replicated by Reams, Lam, and Baker (2012). Baker (2009) and Reams et al. (2012) chose a principal axis factoring method, which explains the common variances among a pool of variables, rather than a principal component analysis without rotation, which was performed by Cutter et al. (2003), and which provides all unique and common variances. Additionally, Cutter et al.'s (2003) approach methods included both positive and negative variables which contributed to the overall SoVI scores. Baker's (2009) and Reams et al.'s (2012) method of principal axis factoring includes only those variables which are important and positive indicators of resilience. A third difference between the methods of Cutter et al. (2003) and Baker (2009) and Reams et al. (2012) is the weighting factor. Cutter et al. (2003) chose not to weight scores, creating no a priori assumption of significance. Baker (2009) and Reams et al. (2012) chose to weight their factors to emphasize the relative importance of the factors.

Reams et al. (2012) performed a principal component analysis on 43 variables for 52 coastal counties along the Gulf Coast from Texas to Florida. These states were all affected by Hurricane Katrina in 2005, as well as the Deepwater Horizon oil spill in 2010, and have similar physical and social makeups. Reams et al. (2012) used 36 variables that are present in the SoVI analysis while adding 7 new variables "that measured additional aspects of vulnerability and resilience, including voting rates among residents, economic resources of local government, and environmental factors". They also weighed their principal components after analysis. Finally, they created a resilience capacity index which allows for the comparison of resilience among the 52 counties in the Gulf Coast region. This method of analysis, along with the groundwork laid by Cutter et al. (2003) and Baker (2009) will be the basis of my analysis for the coastal counties in the Northeast U.S.

CHAPTER 3: METHODS

This study primarily follows the methods laid out by Reams et al. (2012). The same 43 variables were used from the Reams et al. (2012) study and can be found in Table 1. Sixty coastal counties in the states of New York and New Jersey were selected for analysis. The 60 counties were chosen according to NOAA's definition of a coastal county. As defined by the Strategic Environmental Assessments Division of NOAA, a coastal county is one in which "1) at least 15 percent of a county's total land area is located within the Nation's coastal watershed; or 2) a portion of or an entire county accounts for at least 15 percent of a coastal cataloging unit" (https://www.census.gov/geo/landview/lv6help/coastal_cty.pdf). Out of the 60 counties selected, 21 were in New Jersey and 39 were located in New York. Out of the coastal counties in New York, 18 were located along the Atlantic coast and 21 were along the coast of the Great Lakes.

3.1 Data

Data for the 43 variables were primarily collected from the 2000 Census using American Factfinder (http://factfinder2.census.gov/). Economic and local government information was found using the Economic Census from 1997 and 2002. Some variables listed under government (EXPED, LGFREVPERCAP, PROOPTACPC, GENEXPPC) were unlisted for Bronx County, New York County, Queens County, and Richmond County, thus those variables were left as missing data. However, the values were included in the overall value for Kings County. This may slightly skew the results, giving Kings County a higher resilience capacity score and the other metropolitan New York counties slightly lower resilience capacity scores. Birth rates for all counties in New York and New Jersey were collected from the New York Department of Health and the New Jersey Department of Health, respectively (New York Department of Health 2002; New Jersey Department of Health 2002). The values for TRI were collected from the

Environmental Protection Agency's Toxic Release Inventory Program (http://iaspub.epa.gov/triexplorer/tri_release.chemical).

The variable Mean Elevation was calculated by gathering Digital Elevation Models from the USGS National Map Viewer. The files were downloaded as IMG files in 1 arc second data format They were then added as layer files to ArcMap 10.2 and combined into one continuous raster using the "Mosaic" tool found in the Data Management section of Arc Toolbox. The county shapefiles, which were downloaded from the Census Bureau's Tiger file program, were then added as layers. The elevation data for each county was then extracted using the "Zonal Statistics as Table" tool in Spatial Analyst. The lowest mean elevation was Cape May County, NJ, at 1.57 meters above sea level (msl), and the highest mean elevation was Hamilton County, NY at 605.43 msl.

Table 1. List of variables used to construct index

Variable Name	Description
Demographics	
PCTBLACK	Percent African American
PCTINDIAN	Percent Native American
PCTASIAN	Percent Asian
PCTKIDS	Percent of population under 5 years old
PCTOLD	Percent of population over 65
PCTFEM	Percent of population that is female
PCTHISPANIC	Percent Hispanic
MEDAGE	Median age
AVGPERHH	Average number of people per family
BRATE	Birth rate
Social Capital	
PCTF_HH	% female headed household
CTRFRM	% rural farm population
PCTMOBL	% mobile homes
PCTRENTER	% renter occupied homes
PCTNOHS	% over 25 without high school diploma
FEMLBR	% civilian labor force
PCTVLUM	% of population below the poverty level

(Table 1. continued)

Variable Name	Description
TOTCVLBF	% of population participating in the labor force
PCTPOV	% of population below poverty level
HOSPCT03	Hospitals per capita, 2003
NRESPC	Number of nursing home residents per capita
HOUDENUT	Housing density per sq. mile
Economics	
MVALOO	Median value of owner occupied housing
MEDINCOME	Median Income
RPROPDEN	Total value of farm products sold per sq. mile, 2002
EARNDEN	Earnings ($1000) of all establishments per sq. mile
AGRIPC	% employed in primary extractive industries
TRANPC	% employed in transportation, communications, public utilities
SERVPC	% employed in service occupations
PCTHH75	% of households earning over $75,000 per year
SSBENPC	Per capita social security recipients
MEDRENT	Median rent
MAESDEN03	Number of manufacturing establishments per sq. mile
PCTFARM	% of farm land as a percent of total land
SSIREC	% population who receives supplemental security insurance benefits
COMDEVDN	commercial establishments/sq. mile
Government	
EXPED	Local expenditures for education, 2002
PERVOTE	% of population that voted in 1992 general election
LGFREVPERCAP	Local government finance, revenue per capita, 2002
PROPTACPC	property tax, per capita, 2002
GENEXPPC	Direct general expenditures per capita, 2002
Environmental	
MELE	County Mean Elevation
TRI	Lbs. of toxic release per county

(Reams et al. 2012)

3.2 Statistical Analysis and Aggregation Methods

Raw data values were analyzed using SPSS 21 for Windows. A factor analysis was run using the Principal Component Analysis method with Varimax Rotation. Principal Component Analysis is useful for extracting a few meaningful variables out of a large pool. Nine components were produced explaining 82% of the variance. For the purposes of this research, the first 6 components, which explained 72% of the variance, were selected for further analysis. Each component was evaluated to determine its contribution to resilience capacity. Five components were included in the composition of the resilience capacity index. Their original eigenvalues were rescaled to total 100% using a simple proportion. The remaining components were then normalized for each county using the equation found in Reams et al. (2012),

$$V = [(X - X_{min})/(X_{max} - X_{min})],$$

where X is the raw data value and V = the normalized value of the variable. Thus, each value for V now had a value between 0 and 1. Next, the variables were weighted using the rescaled eigenvalues. Then the 5 components for each county were added to create an aggregate score, which became the county’s resilience index score. The resilience scores were then added to ArcMap as a table and joined to the county shapefile. Scores were mapped using the Jenks Natural Breaks classification.

CHAPTER 4: RESULTS

The principal component analysis extracted 9 components which accounted for 82% of the variance. Because the last three components (7, 8, 9) accounted for a minimal amount of the variance and were difficult to interpret, they were not included in any further analysis. The first 6 components were represented by 1) median income; 2) earnings of all establishments per sq. mile; 3) % of population under age 5; 4) % female headed households; 5) local government finance, revenue per capita; and 6) % female. The variables were evaluated for their contribution to resilience capacity. Two components, PCTKIDS and PCTF_HH, came under question because they are generally viewed as indicators of vulnerability within the literature. To determine if they are positively contributing to resilience capacity, I ran two bivariate correlation analyses, one between PCTKIDS and MEDINCOME, and one between PCTF_HH and MEDINCOME. Median income was the variable chosen for correlation because wealth is a universally accepted indicator of resilience capacity throughout the literature. The results showed that the % of population under the age of 5 was significantly positively correlated with median income, with a Pearson's correlation value of 0.428, and a one-tailed significance level of .000. Thus, the variable PCTKIDS can be considered an indicator of resilience capacity. The results of the correlation between % female headed households and median income showed a significantly negative correlation, with a Pearson's coefficient of -0.350 and a one-tailed significance level of .003. Therefore, PCTF_HH was removed from the list of components to be included in the resilience capacity index. The variables associated with the remaining 5 components, their original and rescaled eigenvalues, and their correlation values are listed in Table 2. The rotated component matrix reveals the relationships among the top-loading variables and explains which indicators account for an increased resilience capacity. The rotated component matrix is listed in Table 3.

Table 2. Original and rescaled variance explained by principal components and their correlations

Component	Variable	Original Variance Explained (%)	Rescaled Variance (%)	Correlation
1	MEDINCOME	30.03	44.8176	0.943
2	EARNDEN	18.466	27.5591	0.956
3	PCTKIDS	8.879	13.2512	0.645
5	LGFREVPERCAP	5.399	8.05761	0.908
6	PCTFEM	4.231	6.31445	0.749

4.1 Indicators of Resilience Capacity

The most heavily loaded variable and the factor explaining 45% of the variance (rescaled) is Median Income. The percent of households earning over $75,000 per year and median rent were also highly loaded variables for the first component. These three variables are indicators of wealth or affluence, which is a commonly used indicator of vulnerability or resilience (Cutter et al 2003; Heinz Center 2002, Hudson 2012). Communities with higher incomes overall will be able to afford to adopt a more resilient lifestyle and can more quickly recover from disasters due to insurance and more capital in general (Cutter et al. 2003). The positive score here indicates that counties with a higher median income will be more resilient.

Table 3. Rotated Component Matrix

	Component					
Variable	1	2	3	4	5	6
PCTBLACK	0.059	0.491	0.242	0.663	0.038	0.032
PCTINDIAN	-0.288	-0.02	0.005	-0.068	0.098	-0.371
PCTASIAN	0.48	0.587	0.148	0.012	-0.145	0.081
PCTKIDS	0.476	0.151	0.645	0.265	0.071	-0.015
PCTOLD	-0.131	0.011	-0.881	0.217	0.135	-0.136
PCTFEM	0.137	0.116	0.059	0.04	0.185	0.749
PCTHISPANIC	0.124	0.803	0.328	0.272	-0.062	-0.128
MEDAGE	0.334	-0.231	-0.827	-0.053	0.088	-0.043

(Table 3. continued)

	Component					
Variable	1	2	3	4	5	6
AVGPERHH	0.502	0.395	0.616	0.105	0.168	-0.12
BRATE	0.3	0.373	0.632	0.259	0.1	-0.096
PCTF_HH	-0.297	0.53	0.149	0.723	0.024	0.075
CTRFRM	-0.59	-0.346	0.055	-0.456	0.129	-0.159
PCTMOBL	-0.744	-0.341	-0.029	-0.325	0.038	-0.159
PCTRENTER	-0.362	0.729	0.153	0.26	-0.082	0.254
PCTNOHS	-0.699	0.357	0.064	0.272	0.029	-0.361
FEMLBR	-0.14	0.079	-0.325	0.686	-0.067	0.367
PCTVLUM	-0.047	0.138	-0.027	0.022	0.017	0.078
TOTCVLBF	0.638	-0.14	0.211	-0.103	-0.092	0.538
PCTPOV	-0.867	0.226	0.057	0.211	0.094	-0.022
HOSPCT03	-0.13	-0.081	0.116	0.141	0.186	0.037
NRRESPC	-0.176	-0.257	-0.073	0.595	-0.012	-0.235
HOUDENUT	0.08	0.955	0.072	0.032	-0.041	0.032
MVALOO	0.825	0.369	0.174	-0.047	0.128	0.002
MEDINCOME	0.943	0.069	0.243	-0.134	-0.001	0.015
RPROPDEN	-0.081	-0.39	0.197	0.264	0.071	-0.147
EARNDEN	0.13	0.956	0.096	0.012	-0.033	0.06
AGRIPC	-0.614	-0.286	0.047	-0.39	0.166	-0.272
TRANPC	-0.058	0.423	0.036	0.039	-0.142	-0.116
SERVPC	-0.151	-0.013	-0.209	0.351	0.147	0.064
PCTHH75	0.941	0.147	0.23	-0.05	0.001	0.047
SSBENPC	-0.379	-0.125	-0.85	0.152	0.107	-0.116
MEDRENT	0.908	0.278	0.168	0.03	0.019	-0.094
MAESDEN	0.116	0.955	0.119	0.041	-0.047	0.025
PCTFARM	-0.399	-0.568	0.071	-0.122	-0.08	0.139
SSIREC	-0.896	0.145	0.012	0.195	0.104	-0.064
COMDEVDN	0.152	0.954	0.067	0.008	0.028	0.01
EXPED	0.498	0.325	0.023	0.126	0.473	-0.052
PERVOTE	0.593	-0.32	-0.571	-0.086	-0.054	0.277
LGFREVPERCAP	0.048	-0.07	-0.023	0.052	0.908	0.118
PROPTACPC	0.87	0.148	-0.046	-0.052	0.163	-0.007
GENEXPPC	-0.138	-0.193	-0.122	-0.135	0.876	0.049
MELE	-0.531	-0.287	-0.115	-0.481	0.015	0.131
TRI	-0.063	0.117	-0.027	0.264	0.07	0.415

The second component, explaining 28% of the variance is associated with the earnings of all establishments per square mile. The correlation of this variable (0.956) was extremely close to that of housing density (0.955), manufacturing density (0.955), and the number of commercial establishments per square mile (0.954). This indicates that industrial activity may have a positive correlation with higher resilience. While urbanization is often seen as an indicator of vulnerability, industry can provide economic benefits to communities (Cutter et al. 2003, Heinz 2003). Having a sturdy and diverse economy creates expendable income and can benefit the recovery process.

Our third component is the percent of the population under the age of 5. This factor explains 13% of the variance. A high percentage of children can sometimes be an indicator of vulnerability (Cutter et al. 2003). However, as stated above, it is positively correlated with median income, which we used as an indicator of resilience capacity. This result may be indicative of an overall younger population.

The top-loading factor for component 5 is local government finance, revenue per capita, which explained 8% of the variance. Direct general expenditures per capita was also highly correlated with this dimension. Local government spending is a sign of resilience of the community as a whole because it affects the way a county responds post-disturbance (Reams et al. 2012). A strong local government can be a sign of the ability to quickly recover after a disaster.

Finally, the top-loading factor in component 6 was the percentage of the population that is female. This only accounted for 6% of the variance. This is an interesting result, that may be an anomaly because women are usually thought of as being more vulnerable, and they often have a more difficult time recovering than do men due to “sector specific employment, lower wages, and family care responsibilities” (Cutter et al. 2003). Because the factor was weighted relatively low, it should not have a significant impact on the overall scores.

4.2 Resilience Capacity Index Scores

The resilience capacity scores could range from 0 to 1, with 0 being the lowest, and one being the highest possible score. A high score represents a high relative resilience capacity. A list of counties and their index scores is included in Table 4. Figures 2, 3, and 4 show the spatial distribution of the scores. Franklin County, NY had the lowest score of 0.10, followed by St. Lawrence, NY; Herkimer, NY; Hamilton, NY; and Clinton, NY. Somerset County, NJ, Morris County, NJ, and Hunterdon County, NJ had the highest score of 0.59 followed by Nassau County, NY, and Rockland County, NY. The 20 lowest index scores belonged to counties in New York, while 57% of coastal counties in New Jersey resided in the top 20 highest resilience scores. This may indicate that New Jersey has a relatively higher resilience capacity overall.

The Great Lakes region of New York had some of the least resilient counties, accounting for 16 of the 20 lowest scores. In fact, the 5 counties with the lowest scores (stated above) are in the Great Lakes region. However, the coastal counties in New York along the Atlantic coast are more resilient. Six New York counties are in the 10 most resilient counties, and all of them are on the east coast of the state.

Table 4. List of counties and their Resilience Capacity Index Scores

County	Index Score	County	Index Score
Franklin, NY	0.10	Ontario, NY	0.28
St. Lawrence, NY	0.14	Camden, NJ	0.29
Herkimer, NY	0.16	Wayne, NY	0.29
Hamilton, NY	0.16	Kings, NY	0.29
Clinton, NY	0.17	Atlantic, NJ	0.30
Greene, NY	0.17	Salem, NJ	0.30
Chautauqua, NY	0.18	Monroe, NY	0.30
Wyoming, NY	0.18	Essex, NJ	0.33
Cattaraugus, NY	0.19	Passaic, NJ	0.35
Cayuga, NY	0.19	Dutchess, NY	0.35
Lewis, NY	0.20	Gloucester, NJ	0.37
Bronx, NY	0.20	Richmond, NY	0.37

(Table 4. continued)

County	Index Score	County	Index Score
Orleans, NY	0.21	Burlington, NJ	0.39
Jefferson, NY	0.21	Mercer, NJ	0.40
Livingston, NY	0.22	Warren, NJ	0.40
Oswego, NY	0.22	Union, NJ	0.41
Columbia, NY	0.22	Orange, NY	0.42
Niagara, NY	0.23	Middlesex, NJ	0.43
Erie, NY	0.23	Bergen, NJ	0.46
Ulster, NY	0.24	Sussex, NJ	0.47
Ocean, NJ	0.24	Monmouth, NJ	0.47
Cape May, NJ	0.24	Suffolk, NY	0.51
Hudson, NJ	0.25	Westchester, NY	0.51
Schenectady, NY	0.26	New York, NY	0.52
Albany, NY	0.26	Putnam, NY	0.54
Queens, NY	0.26	Rockland, NY	0.55
Cumberland, NY	0.26	Nassau, NY	0.56
Genesee, NY	0.27	Hunterdon, NJ	0.59
Onondaga, NY	0.27	Morris, NJ	0.59
Rensselaer, NY	0.27	Somerset, NJ	0.59

Of the twenty counties with the lowest median income (Component 1), 18 were in New York, and 14 of those counties were considered in the Great Lakes region of the state. Of the 20 wealthiest counties, 12 were in New Jersey, and 8 in New York. None were in the Great Lakes region. For Component 2 (Earnings of all establishments per square mile) 19 of the 20 counties with the lowest earnings belonged to New York, and 17 of those were in the Great Lakes region of the state. Of the 20 counties with the highest earning density, 11 were in New Jersey and the rest in New York on the Atlantic Coast. The most top-loading factor for component 3 was the percent of population under 5. Nineteen out of the 20 counties with the lowest percentages were in New York – 16 in the Great Lakes area. Eleven of the 20 highest percentages were in New Jersey, one was in the Great Lakes region.

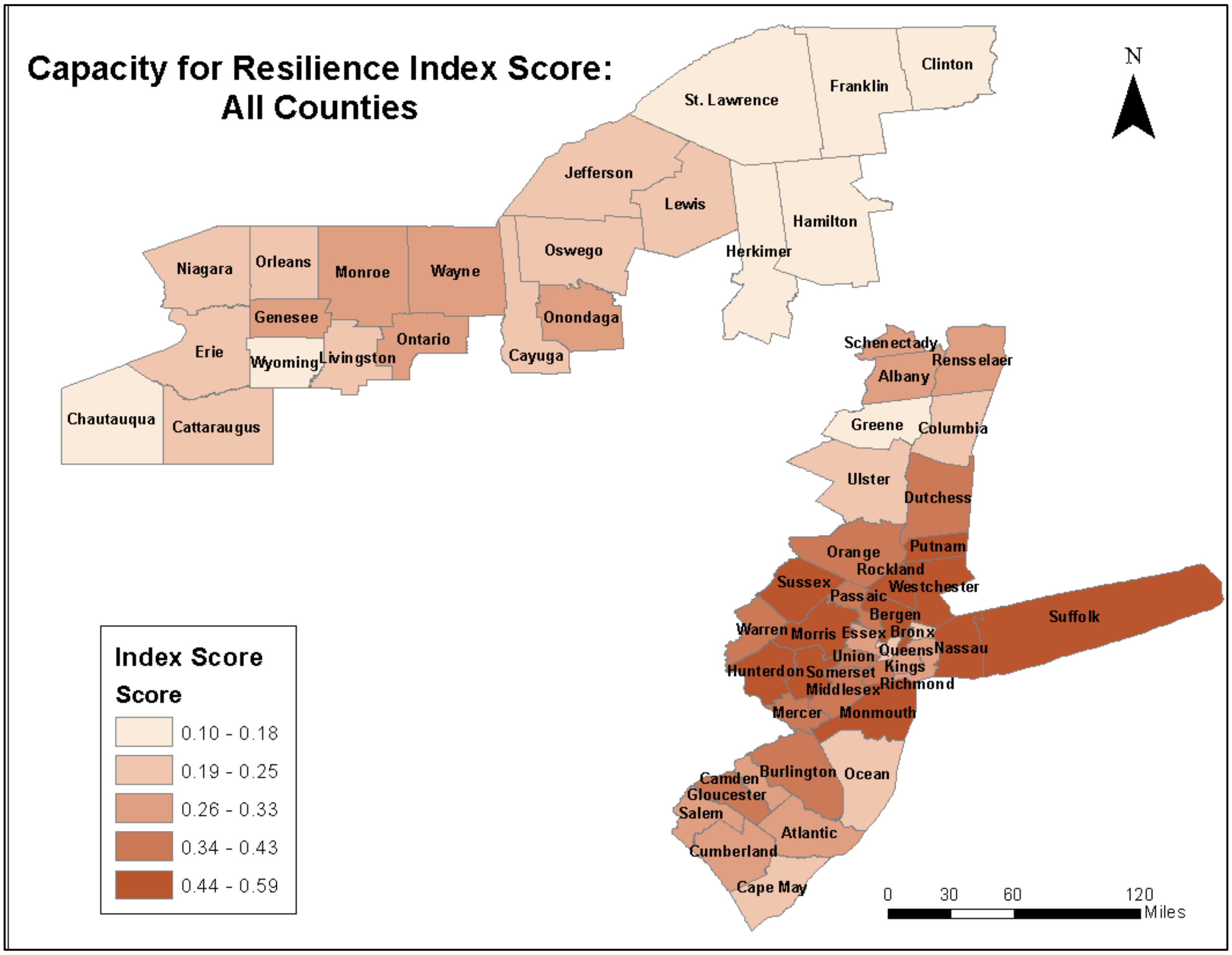

Figure 2. Spatial Distribution of Index Scores for all Coastal Counties in New York and New Jersey

On the other hand, for the local government finance revenue per capita (Component 5), counties in New Jersey accounted for 14 of the twenty counties with the least amount of revenue, while the fifteen of the top 20 counties with the highest local government revenue per capita were in New York, 7 of which were in the Great Lakes area. This, of course, could be attributed to the fact that population in the seven Great Lakes counties are relatively low. Finally, the last component, percent female, has 16 out of the 20 lowest percentages from New York counties. However, New York counties also make up the majority of the 20 highest percentages, with 13 from New York and 7 from New Jersey.

Table 5. Minimum and maximum values for each variable and their related county

Variable	Min	Max	Min County	Max County
MEDINCOME	27611	79888	Bronx, NY	Hunterdon, NJ
EARNDEN ($1000)	32.93	10461898	Hamilton, NY	New York, NY
PCTKIDS (%)	4.3	8.2	Hamilton, NY	Bronx, NY
LGFREVPERCAP	2484	5903	Ocean, NJ	Kings, NY
PCTFEM (%)	38.7	53.5	Camden, NJ	Bronx, NY

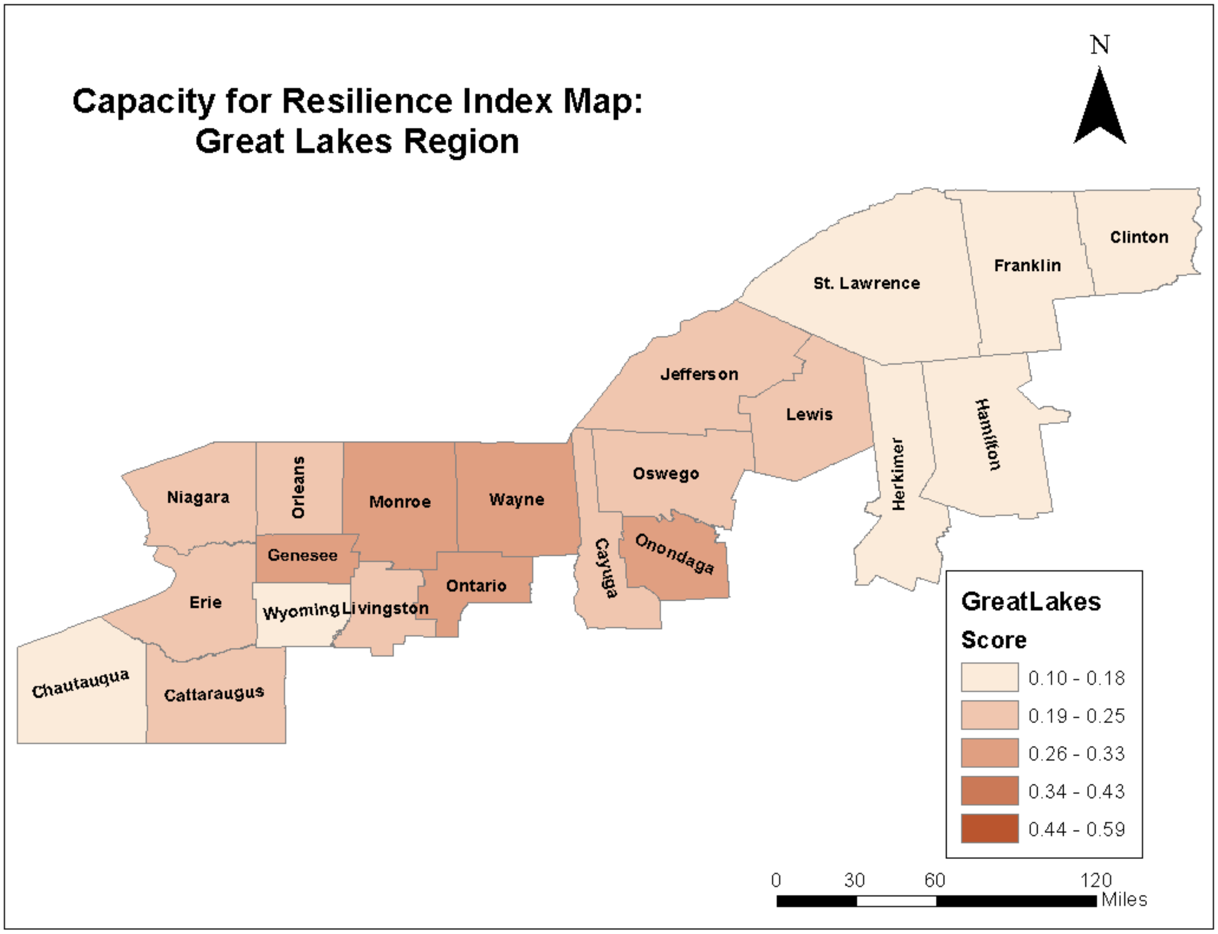

Figure 3. Spatial Distribution of Index Scores for NY Counties near the Great Lakes

While New Jersey has a higher overall median income and earning density, New York counties have a greater local government finance per capita and higher percentages of females. However, since the first two components had a combined weight of 72.4%, counties which had high scores in these categories were more likely to have a higher relative capacity for resilience.

This indicates that the New York counties along the Great Lakes may have a lower capacity for resilience due to low median income and a lack of industry.

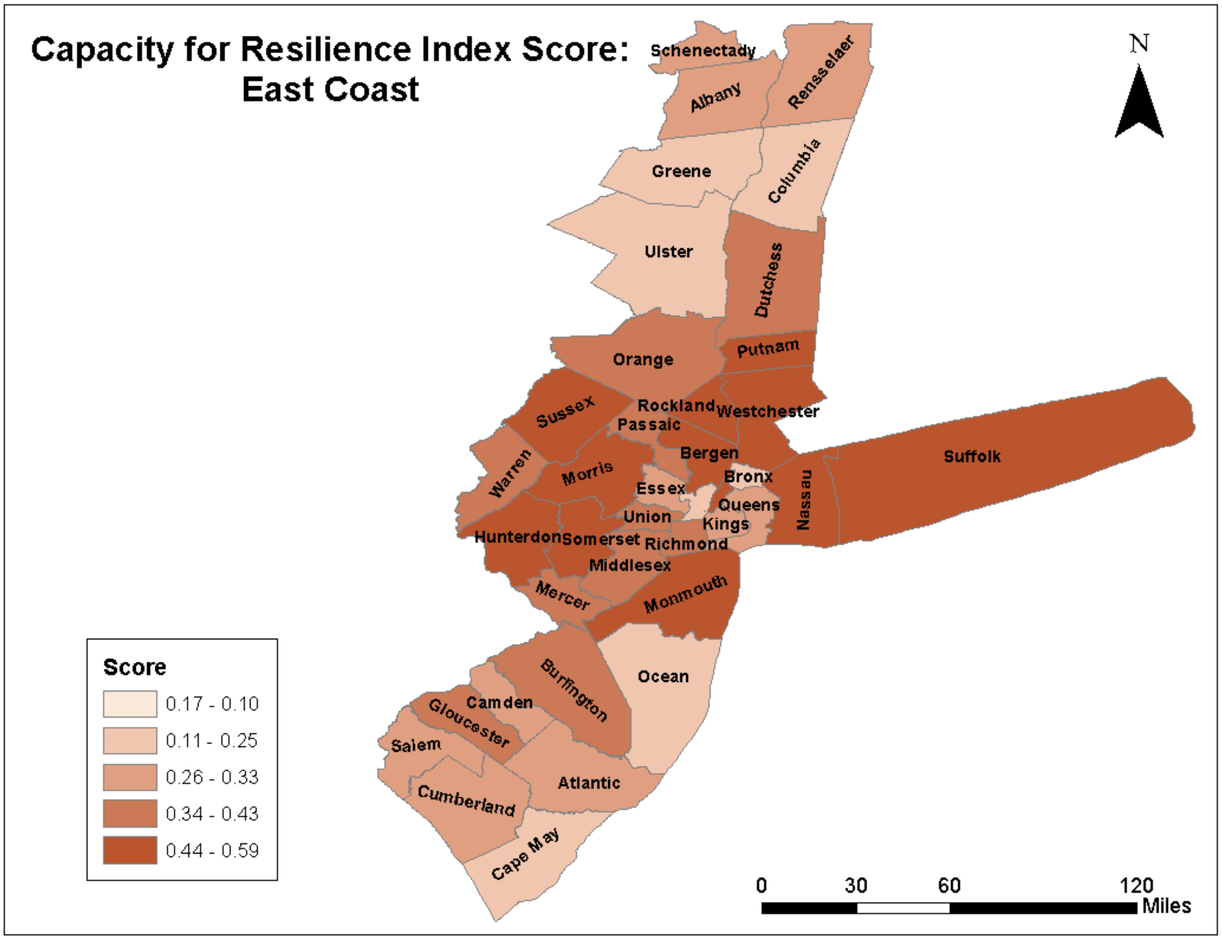

Figure 4. Spatial Distribution of Index Scores for Counties along the East Coast

4.3 Comparison with Other Studies

4.3.1 Cutter et al. (2003)

Direct comparison with Cutter et al. (2003) is difficult since their study measured vulnerability, while this study measures resilience capacity. However, as discussed above, the two concepts are similar in theory and it is possible to compare results. The primary component in Cutter et al (2003) was “personal wealth” measured by per capita income, household income and house values, median rent, and poverty. The amount of household income over $75,000 along with house values and median rent loaded positively. This corresponds with our first component, which also measured wealth. Their second component was age and the third was "density of the built environment." Again, this corresponds with the results of this study, which showed industry, or the built environment, as the second factor, and age as the third. It is interesting to see that although Cutter et al. (2003) assessed social vulnerability for the entire nation, the same indicators are prevalent in both studies. This, in the least, means that wealth, age, and building density impact how vulnerable or resilient a community may be.

4.3.2 Reams et al. (2012)

The methodology for this research was taken directly from Reams et al. (2012), so it will be interesting to assess how the results compare, and to examine differences in the two regions. The first component for Reams et al. (2012) was local government expenditures for education, which accounts for education, but also the economic resources of the local government, which is represented in my results in the 5th component. Their second variable was median income, which is the second component in this study. Finally, their 5th component, the percent of the population under five years of age, was the result for the 3rd component in this study. Local government finances, median income, and the age of the population are important factors in both the Gulf Coast and Northeastern U.S.

Table 6. Comparison of results from related studies

Component	Cutter et al. (2003)	Reams et al. (2012)	Gootee
1	Per capita income	Expenditures for education	Median income
2	Median age	Median Income	Earnings per sq. mile
3	# Commercial establishments/sq mile	% labor force that is female	% population under 5
4	% employed in extractive industries	Mean elevation	% female head of house (excluded)
5	Percent mobile homes	% population under 5	local government revenue, per capita
6	% African American	% voters in 1992 election	% female population

4.4 Verification: Correlating Resilience Capacity and Public Assistance Grants

The principal component analysis and corresponding resilience capacity index identifies that the coastal counties with the highest index scores are those that are relatively wealthier and have greater economic health. New Jersey tends to have a greater capacity for resilience as a whole, but counties in New York along the east coast, like New York, Suffolk, Westchester, Putnam, and Rockland are also high in resilience capacity. Validation techniques are one area where these kinds of analyses, which use statistical measures to describe complex systems such as social-ecological resilience, are lacking. Schmidtlein et al. (2008) performed a sensitivity analysis on the techniques Cutter et al. (2003) used in developing their Social Vulnerability Index. They determine that while the analysis is robust both temporally and at different scales (i.e. county level versus census tract level), changing the more subjective parts of the analysis, such as type of rotation and weighting systems can significantly affect results. This is why validation of these analyses are important. Yet standardized verification techniques are lacking, and there are currently no significant variables that can verify these methods. This is apparent within both Cutter et al (2003) and Reams et al (2012). Both studies attempted to verify their results using different variables. Cutter et al (2003) used frequency of presidential disaster declarations while Reams et al. (2012) used a variable related to oil and gas production along the Gulf Coast. Neither study had significant findings. Nevertheless, I will attempt a verification of my findings by looking at the damages to the region after disasters and specifically after Hurricane Sandy.

FEMA's Public Assistance Grant Program allocates grants following presidentially declared disasters or emergencies in order to assist in the recovery of the area. The underlying statute that supports the program is the Robert T. Stafford Disaster Relief and Emergency

Assistance Act (Stafford Act). The Stafford Act outlines four components of eligibility. They are cost, work, facility, and applicant (FEMA 2012). Eligible applicants are defined as local, state, and federally recognized tribal governments as well as certain private non-profit organizations, which provide services such as education, utilities, medical and custodial care, and other services that may be performed by a governmental agency (FEMA 2013b). The grant is used to assist in debris removal, repair or replacement of publicly owned facilities, emergency planning, and hazard mitigation programs (FEMA 2013e). The work must be completed in a disaster area and be the result of a major disaster event (FEMA 2013a). As of February 2014, FEMA had allocated over $2.4 billion throughout the state of New York, and over $1.1 billion throughout New Jersey (FEMA 2014a; FEMA 2014b).

Public Assistance (PA) grants provide us with a variable that can potentially identify the damages to an area after a disaster and the amount of aid required for recovery. The amount of money allocated to a county after a disaster can be a sign of its relative resilience. I assume that counties which receive more public assistance grants from FEMA receive more overall damages and are more reliant on support from the federal government. I expect a negative correlation between public assistance grants and resilience capacity, which would show that counties with a relatively high resilience capacity to require fewer federal dollars for recovery and those with low resilience capacity to require more. A bivariate analysis of the amount of PA received by counties and their resilience capacity index score could show if such a correlation exists.

The amount of money given in FEMA PA grants to each coastal county in New York and New Jersey from 2000-2011 was collected from the U.S. General Services Administration via Data.gov. Data was also collected on PA grants allocated immediately after Hurricane Sandy. Each county’s PA was normalized by calculating amount of assistance per capita. A list of PA grants allocated to each county for Hurricane Sandy and for the time period of 2000-2011 can be found in Tables 7 and 8, respectively. Their spatial distributions are mapped in Figures 5 and 6.

Table 7. List of counties that received PA Grants after Hurricane Sandy

County	PA Per Capita	County	PA Per Capita
Bronx, NY	\$1.59	Mercer, NJ	\$30.60
Richmond, NY	\$2.88	Bergen, NJ	\$32.97
Gloucester, NJ	\$3.07	Somerset, NJ	\$34.67
Camden, NJ	\$3.93	Rockland, NY	\$40.12
Orange, NY	\$7.00	Westchester, NY	\$41.18
Burlington, NJ	\$7.96	Hunterdon, NJ	\$61.69
Greene, NY	\$8.16	Union, NJ	\$65.34
Passaic, NJ	\$14.31	Hudson, NJ	\$65.77
Kings, NY	\$15.25	Atlantic, NJ	\$86.79
Salem, NJ	\$15.60	Middlesex, NJ	\$87.64
Putnam, NY	\$16.23	Suffolk, NY	\$97.26
Ulster, NY	\$16.38	Queens, NY	\$209.99
Warren, NJ	\$16.39	Nassau, NY	\$260.47
Cumberland, NJ	\$18.94	Monmouth, NJ	\$325.47
Sussex, NJ	\$23.63	Ocean, NJ	\$380.97
Essex, NJ	\$29.63	Cape May, NJ	\$425.39
Morris, NJ	\$30.20	New York, NY	\$475.30

A bivariate correlation analysis was run between PA per capita and the resilience capacity index score for each county with a one-tailed t-test. The analysis was run for both the data set that ranged from 2000-2011 and the Hurricane Sandy data set. The analysis returned the Pearson's Correlation Coefficient and the statistical significance of the correlation, which is shown in Table 9. The results for the 2000-2011 data returned a Pearson's correlation of 0.62, and the Hurricane Sandy data returned a Pearson's correlation of 0.53. Neither correlation was statistically significant.

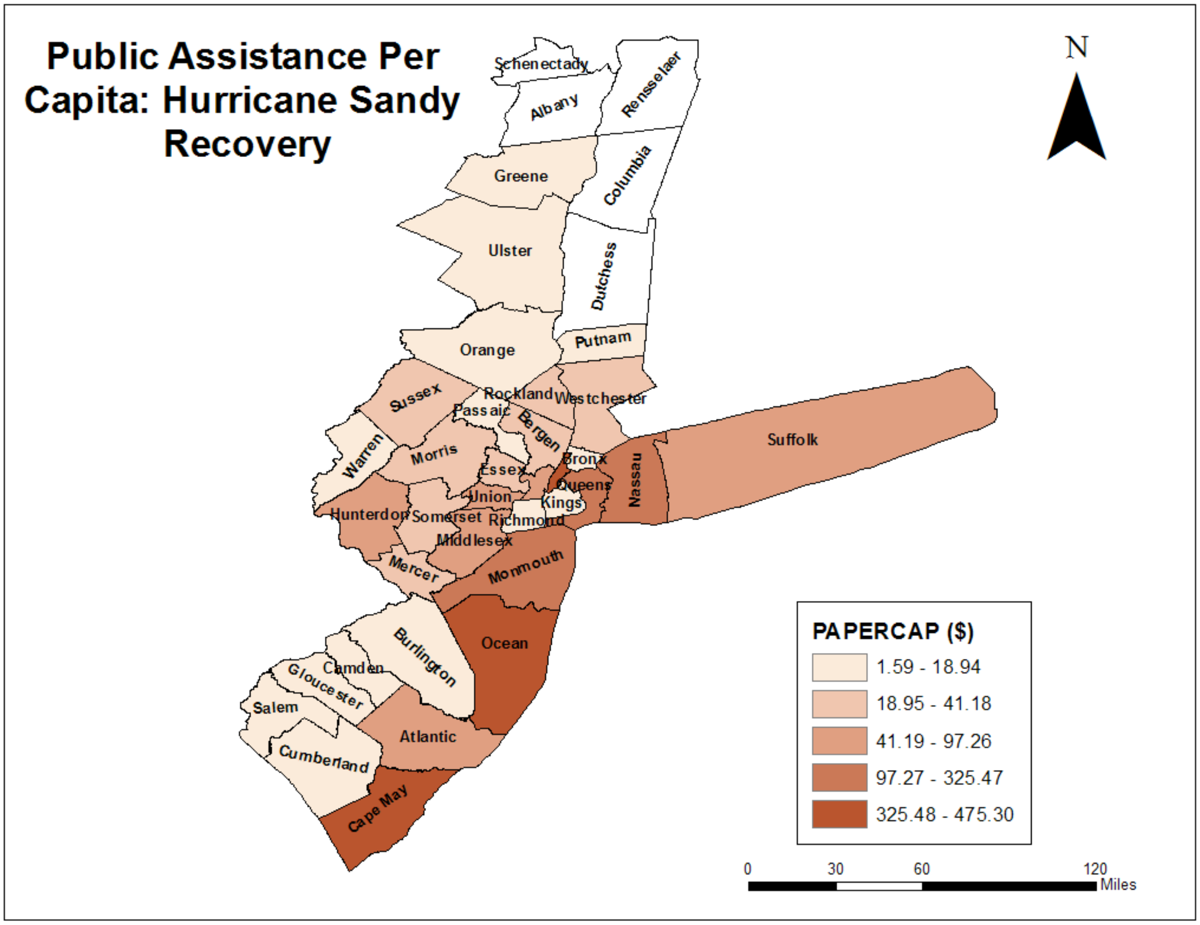

Figure 5. Spatial distribution of FEMA Public Assistance Grants Associated with Hurricane Sandy, Per Capita

Table 8. PA Grants per capita: 2000-2011

County	PA Per Capita	County	PA Per Capita
St. Lawrence, NY	$0.06	Genesee, NY	$41.01
Jefferson, NY	$0.09	Suffolk, NY	$41.05
Bronx, NY	$0.37	Morris, NJ	$43.86
Queens, NY	$1.60	Chautauqua, NY	$44.72
Kings, NY	$1.76	Ontario, NY	$45.34
Monroe, NY	$11.11	Warren, NJ	$52.03
Onondaga, NY	$13.28	Putnam, NY	$54.00
Richmond, NY	$13.91	Albany, NY	$55.59
Camden, NJ	$15.28	Atlantic, NJ	$56.01
Wyoming, NY	$15.41	Lewis, NY	$57.35
Hudson, NJ	$19.87	Westchester, NY	$59.41
Gloucester, NJ	$22.13	Franklin, NY	$60.03
Cayuga, NY	$22.14	Rockland, NY	$61.56

(Table 8. continued)

County	PA Per Capita	County	PA Per Capita
Niagara, NY	$22.76	Clinton, NY	$62.30
Essex, NJ	$23.95	Schenectady, NY	$70.74
Orleans, NY	$24.33	Sussex, NJ	$71.15
Oswego, NY	$25.34	Cumberland, NJ	$74.19
Ocean, NJ	$25.43	Salem, NJ	$86.23
Mercer, NJ	$25.46	Orange, NY	$107.85
Wayne, NY	$27.44	Rensselaer, NY	$109.21
Middlesex, NJ	$28.99	Livingston, NY	$123.88
Dutchess, NY	$33.50	Erie, NY	$149.32
Burlington, NJ	$34.39	Herkimer, NY	$158.68
Monmouth, NJ	$34.69	Columbia, NY	$165.90
Union, NJ	$35.07	Ulster, NY	$214.67
Hunterdon, NJ	$35.51	Hamilton, NY	$248.99
Bergen, NJ	$35.69	Cape May, NJ	$251.74
Nassau, NY	$36.90	Cattaraugus, NY	$278.85
Somerset, NJ	$37.77	Greene, NY	$663.37
Passaic, NJ	$38.58	New York, NY	$2,350.41

While the results of the bivariate analyses did not show any statistical correlation between recovery and capacity for resilience, the recovery efforts of the Northeast are worth mentioning. On December 9, 2012, Mayor Bloomberg of New York City commissioned a report and evaluation on the city's response before, during, and after Hurricane Sandy. In May 2013, the commission delivered a report on the city's response efforts and made recommendations as to where there could be improvement in the city's performance. The report included input from many sectors including "nonprofit partners, New York State agencies, and an extensive set of hearings held by the New York City Council" ("NYC Hurricane Sandy After Action Report" 2013). A total of 59 recommendations were made in the report. They identify six core areas of improvement: 1) communication; 2) general healthcare and facility evacuations; 3) public safety; 4) general and special medical need sheltering; 5) response and recovery logistics; and 6) community recovery services (“NYC Hurricane Sandy After Action Report” 2013). This effort by the city’s local government shows their ability to reorganize after a disturbance and to learn from their experiences indicating a higher level of resilience capacity.

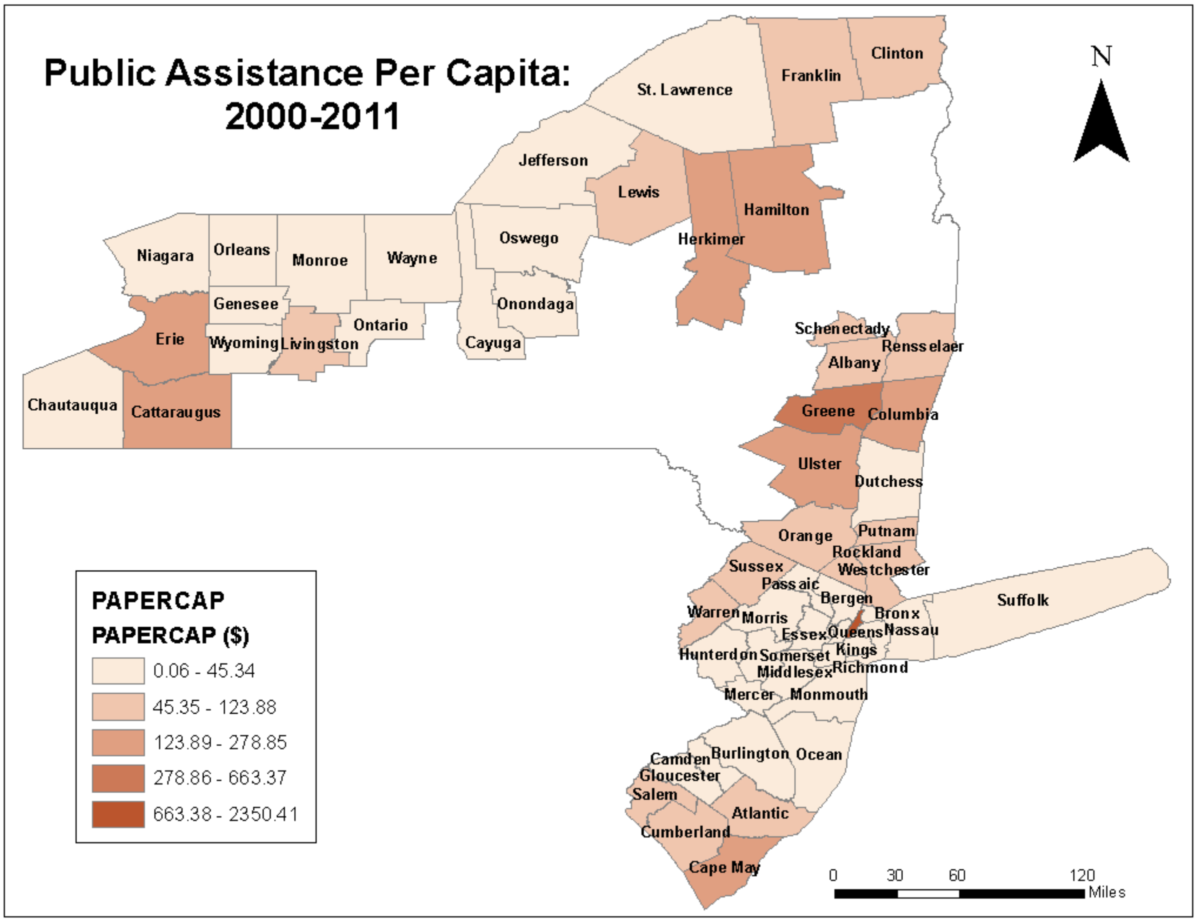

Figure 6. Spatial Distribution of FEMA Public Assistance Grants Per Capita for 2000-2011

Table 9. Bivariate Correlation Results

Data Set	N	Pearson's Correlation	Significance
2000-2011	60	0.062	0.318
Post-Sandy	34	0.053	0.383

CHAPTER 5: CONCLUSIONS AND POLICY IMPLICATIONS

Coastal communities are globally some of the most vulnerable communities. High population densities as well as a densely built environment along the coast are staged for a catastrophic event almost at any moment. Hurricanes and floods always have been threats to coastal communities, but they are exacerbated by the compounding of climate change and sea level rise. Many coastal communities are seeing a relative sea level greater than that of the global average due to the combination with subsidence. Additionally, the IPCC expects to see a greater frequency and intensity in tropical storms and hurricanes. The natural environment, which serves as a buffer between communities and weather events, is being rapidly deteriorated due to intense development on the coast. The combination of these threats and hazards leave coastal communities extremely vulnerable. We saw the embodiment of this in October 2012 when Hurricane Sandy hit the Northeastern coast of the U.S. The storm left hundreds of thousands without power or even homes and the federal government has since allocated over $3 billion in public assistance grants to state, local, and tribal governments in New Jersey and New York to assist with recovery. This event showed just how vulnerable coastal communities are to coastal hazards. Identifying the factors which lead to vulnerability can assist policy-makers in creating management plans which will create a capacity for resilience and adaptation in these communities.

This study created an index for the capacity for resilience in 60 coastal counties in New York and New Jersey. I performed a principal component analysis with varimax rotation on 43 variables which are defined as indicators of resilience. The results provided 6 major components which explained 72% of the variance. These results were normalized and weighted to create index scores which were used to assess the relative capacity for resilience among the 60 selected counties. The major variables affecting resilience capacity were associated with wealth, economy, age, local government finances, and gender. I compared these results with Reams et al. (2012), which showed that variables indicating wealth, age, and local government spending were factors affecting the capacity for resilience in both the Northeast and the Northern Gulf of Mexico.

New Jersey was identified as having an overall higher capacity for resilience than New York. New York State was divided into two regions, the Atlantic Coast and coast along the Great Lakes. Those counties situated along the Great Lakes were found to have the least capacity for resilience, while those in the eastern portion of the state had some of the highest resilience capacity scores. This is due to the fact that the Great Lakes communities have less wealth, a smaller economy, and less government financing. While these counties generally are not affected by hurricanes, they are still subject to harsh winter storms and flooding, so efforts should be made to decrease the vulnerability of this area.

Validation of the resilience capacity index was attempted by measuring it against the amount of FEMA Public Assistance grants received throughout the region from 2000-2011 and immediately following Hurricane Sandy. A bivariate correlation was run; however, it returned no significant correlations between grant money and resilience. Although there was no statistical significance in the relationship between resilience capacity and public assistance, it is clear through the actions of local government leaders like Mayor Bloomberg that there is a relatively high capacity for resilience in the region along the Atlantic Coast. This is demonstrated by their ability to reorganize effectively after a disturbance as devastating as Hurricane Sandy was.

The resilience capacity index can be a useful tool for policy-makers to determine which areas are more vulnerable and why, and which areas will be able to recover and reorganize more quickly after a disaster. Of course, the tool is not perfect and greater depth of social-ecological studies will be needed, but the index can help decision-makers and community leaders hone in to areas that seem to be lacking in resources, such as the counties near the Great Lakes. Additionally, validation techniques are needed to assess the results of these types of studies.

Census 2000 data was chosen for this analysis so that the results would be on the same temporal scale as those of Reams et al. (2012), which would allow for comparisons. However, further analysis can be done using Census data from 2010. Those results could be used to determine how levels of resilience have changed since 2000. They could be related to actions taken after Hurricane Katrina, which created a renewed level of awareness of coastal hazards, or after the IPCC 2007 report, which predicted rising sea levels and stronger storms. Additionally, future research could include the actions of local governments in response to coastal threats and climate change. Analysis of local ordinances and policy changes responding to disasters could shed light on a community's adaptive capacity at a larger scale. For example, the actions taken as a result of the report commissioned by Mayor Bloomberg show a higher level of resilience capacity at the local government level. Again, there will be challenges with quantification of these variables, but they may indicate whether local governments are enacting policies to make communities more resilient. Continuing studies across time and space can enhance the level of understanding of which variables lead to a higher capacity for resilience.

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